APPENDIX D

Development of COC Mass Flux,
LNAPL Mole Fraction,
Aqueous Concentration Targets, and
Depletion Estimates from LNAPL in the Saturated Zone

APPENDIX D TABLE OF CONTENTS

TABLES

FIGURES

D-1.0 INTRODUCTION AND OBJECTIVES

Appendix D presents an evaluation of the target mass fluxes of methyl tertiary-butyl ether (MTBE) and benzene in groundwater at the downgradient edge of the light nonaqueous phase liquid (LNAPL) area (source area), and estimates of the timeframe for the attainment of the target mass fluxes. Specifically, the objectives of the evaluation were to:

- estimate the dissolved-phase concentrations of MTBE and benzene in groundwater that are in contact with LNAPL and a target maximum groundwater concentration of each constituent that results in attainment of the mass flux targets
- relate the target maximum groundwater concentration to mole fractions of MTBE and benzene in the LNAPL present in the saturated zone
- estimate the necessary LNAPL composition reductions required to meet the mass flux targets
- estimate a timeframe to deplete MTBE and benzene from the saturated zone LNAPL to meet the target mass fluxes, and corresponding target concentrations and LNAPL mole fractions

The following sections present the development of the MTBE and benzene mass flux targets, the approach used to estimate target concentrations and mole fractions required to meet mass flux targets, and the estimation of the time to attain these targets in groundwater in contact with the LNAPL source zone.

D-2.0 MASS FLUX TARGETS

Contaminant mass flux, or mass discharge, is the rate at which chemical mass passes through a defined cross-sectional area. Total mass flux is the product of groundwater discharge and contaminant concentrations, and is expressed in units of mass per time (e.g., grams per day [g/d]).

Mass flux targets protective of California primary and secondary Maximum Contaminant Levels (MCLs) for MTBE (13 micrograms per liter [μg/l] and 5 μg/l, respectively) and the California primary MCL for benzene (1 μg/l) were estimated for the Terminal off-site areas. The mass flux targets were developed to evaluate potential impacts associated with potable use of groundwater from a potential future supply well downgradient of the Terminal. The method involves estimating the mass flux of each constituent from a source zone to a potential future supply well under various potential extraction rates that result in concentrations at or below the criteria.

The concentration in a future supply well can be estimated using the following approach (Einarson and Mackay 2001):

$$C_{sw} = M_f / Q_{sw}$$

Where:

C_{sw} = maximum concentration of contaminant in water extracted from the supply well (mass/volume),

M_f = total mass flux (mass/time), and

Q_{sw} = pumping rate from a supply well (volume/time).

Use of this approach conservatively assumes that the capture area of a potential future supply well completely intercepts the dissolved-phase plume, that the source strength is constant, that there is no biological or chemical attenuation of the dissolved-phase plume from the target flux location to the supply well, and that the groundwater flow field is constant in rate and direction.

The above equation can be rearranged to calculate the mass flux that would be protective of the MCLs for a specified supply well pumping rate as follows:

$$M_f = C_{sw} * Q_{sw}$$

A range of potential future supply well pumping rates was obtained from the City of San Diego Reservoir Management Study (Boyle Engineering 1995, "the water management study"). The water management study included a review of the factors governing the use and management of the San Diego area groundwater basins, and how each basin could be used to augment the City's water supply. For the Mission San Diego Basin, the study reported a range of well yields in the basin from 35 gallons per minute (gpm) to 1,000 gpm. The study indicates that the most economically feasible groundwater development alternative includes extracting up to the safe yield of the basin, approximately 2,400 acre-feet per year (ac-ft/yr) (approximately 1,500 gpm). The alternative suggests eight groundwater supply wells would be used, which results in approximately 188 gpm per well, if pumping is distributed evenly. The City of San Diego recently published the "San Diego River System Conceptual Groundwater Management Plan," (CH2MHill 2003) which outlined potential groundwater extraction scenarios for the San Diego River Basin. For the Mission Valley Groundwater Basin, a water budget analysis indicated a safe yield of 2,100 ac-ft/yr, but that only about 1,000 ac-ft/yr is currently available due to other uses. The study concluded that feasible groundwater development in this basin would include "12 wells located in the upper portion of the basin along the San Diego River." This alternative was based on numerical modeling. If 12 wells extract groundwater at 1,000 ac-ft/year (620 gpm) with an equal distribution of pumping, each well would extract approximately 52 gpm.

Table D-1 and Figure D-1 present an evaluation of the MTBE and benzene mass flux targets for a range of potential future supply well pumping rates. As indicated in the table and on the figure, the MTBE mass flux protective of the California secondary MCL (5 μg/l) ranges from 1 to 27 g/d, and the benzene mass flux protective of the California primary MCL (1 μg/l) ranges from 0.2 to 5.5 g/d. For the potential supply well pumping rate of 188 gpm, the mass flux target for MTBE is 5 g/d; for benzene, the mass flux target is 1 g/d.

It is important to note that the calculated wellhead concentration is conservative and likely overestimates expected concentrations. This is because the estimated yield of 188 gpm is likely lower than would be expected, given that well yields up to 1,000 gpm have been reported for this basin. In addition, as stated above, the methodology used assumes that the capture zone for the hypothetical supply well intercepts the entire plume of MTBE-affected groundwater. The City's groundwater management plan also indicates development above 1,000 ac-ft/yr could likely be attainable during most water years.

D-3.0 ESTIMATES OF LNAPL BOUNDARY MASS FLUX

The following sections describe the empirical mass flux method, the LNAPL boundary mass flux transect monitoring network, groundwater flow and hydraulic parameters, and the analytical data used in the calculations.

D-3.1 Mass Flux Transect Method

This section provides a summary description of the empirical mass flux method. A more complete description of this method is presented in "Estimating Mass Flux for Decision-Making: An Expert Workshop" (API 2003b). The Transect Method (API 2003b) was used to calculate mass flux across the property boundary. This method uses estimates of groundwater discharge and analytical data from samples collected from monitoring wells located across a transect oriented orthogonal to groundwater flow.

The total mass flux, M_f, along a transect is calculated as follows:

$$M_f = \sum_{i=1}^{i=n} C_i * A_i * q_i$$

Where:

M_f = total mass flux through the vertical cross section (mass/time)

C_I = contaminant concentration calculated with analytical data and interpolated values across the plume transect (mass/volume)

A_i = cross-sectional area associated with concentration (area)

q_i = specific discharge (Darcy velocity) of groundwater through the cross sectional area A_i (volume/area/time)

The groundwater specific discharge is calculated using Darcy's Law:

$$q_i = K_i i_i$$

Where:

K_i = hydraulic conductivity associated with area A_i (length/time)

i_i = hydraulic gradient associated with area A_i (length/length)

Because plume concentrations and groundwater discharge vary along a cross section, the mass flux is estimated within discrete subareas (i…n), and then summed to estimate the total mass flux of the plume along that transect.

The transect method is applicable to a single snapshot in time of the concentration distribution in a cross section of a plume. Concentration distributions, physical parameters, and other hydraulic data used in the mass flux evaluation were obtained from analysis and interpretation of analytical data, geologic logs, and other information obtained from site characterization, and are discussed below.

D-3.2 Empirical Data Evaluation and Methods

Transect Location and Monitoring Network

The mass flux through a transect at the edge of the LNAPL-affected area was calculated using groundwater level and analytical data from the Mission Valley Terminal quarterly monitoring event in August 2003 (third quarter 2003), and for an assumed high water level condition. The August 2003 mass flux calculations were evaluated as a baseline condition where concentration distributions, the horizontal and vertical extent of groundwater in contact with LNAPL, maximum concentrations in groundwater contacting LNAPL (effective solubility), and groundwater flow and specific discharge could be estimated. The transect location was selected based on the estimated downgradient extent of the LNAPL-affected area as interpreted from LIF data (LFR 2003b). In addition, the transect is relatively close to the groundwater extraction system and the mass flux estimates can be "calibrated" to or constrained by the mass removal rates from the extraction wells.

In recent years, water levels in the offsite LNAPL-affected area have been near historically low conditions as a result of remedial groundwater extraction. To evaluate concentration reductions required to meet mass flux targets, the August 2003 mass flux transect was modified to estimate the mass flux for a high water level condition. The high water level condition will occur when remedial extraction is discontinued and will result in an increased amount of groundwater contacting residual LNAPL. The mass fluxes of MTBE and benzene for this condition were compared to mass flux targets to estimate concentration and concentration distributions that will result in attainment of the target mass flux. For this condition, the concentration of each constituent in groundwater in contact with LNAPL represents an effective solubility in equilibrium with target LNAPL mole fractions that meet mass flux targets.

The transect extends approximately from the canyon boundary in the north/northeast toward Murphy Canyon creek in the east and includes wells R-43AS, R-43AD, R-9, R-10, and R-18 (Figure D-2). The transect includes the entire width of the 1 µg/l MTBE isoconcentration contour in August 2003, as shown on Figure D-2 (LFR 2003a). The width of the affected groundwater in this area is relatively consistent between quarters and is well represented by the August 2003 MTBE plume width.

The monitoring wells along the transect are screened within the alluvium, which extends from the ground surface to approximately 56 feet below ground surface (bgs) and overlies the Friars Formation sandstone in this area. Table D-2 presents transect monitoring well construction details and August 2003 groundwater elevations and MTBE and benzene concentrations. Historically, LNAPL has been measured in wells R-9 and R-10, ranging from approximately 2.5 feet to 0.01 foot thick. Water levels across the transect have generally decreased by approximately 4 feet since 1992.

Transect Subarea Discretization - Interpolation of Hydraulic Conductivity Values

Because plume concentrations and groundwater discharge vary along the transect and in cross section, the section is divided into discrete subareas for individual mass flux calculations, which are then summed together to estimate the total mass flux across the transect. The discrete subarea dimensions in vertical cross section across the LNAPL boundary transect are based on the distribution of hydraulic conductivity values, which were interpolated using indicator kriging. The initial values of hydraulic conductivity were obtained from interpretations of lithology and aquifer test data. The subarea dimensions were further refined based on the distribution of the dissolved-phase plume in vertical cross section, including the assumed distribution of groundwater in contact with residual LNAPL as estimated from LIF data. Figure D-3 presents the subarea discretization and the hydraulic conductivity values assigned to each subarea. As a result of the indicator kriging evaluation, values of 150, 50, and 20 feet per day (ft/d) were assigned to high, medium, and low hydraulic conductivity materials, respectively. For the Friars Formation, a hydraulic conductivity of 1 ft/d was assigned, which is consistent with published values for this formation type. The hydraulic conductivity values are consistent with those used in the numerical flow and transport model described in Appendix A. No adjustments to hydraulic conductivity were made to account for LNAPL saturation. Where more than one value of hydraulic conductivity as assigned from the statistical analysis was included in a subarea, the geometric mean value of the hydraulic conductivities associated with that subarea was used. For the high water level condition, hydraulic conductivity values for the re-saturated vadose zone materials were estimated from permeability testing of soil cores (see Appendix B).

Calculation of Groundwater Flow Rates and Specific Discharge Across the Transect

The specific discharge for each snapshot in time within each subarea was calculated with the assigned subarea hydraulic conductivity and an average horizontal hydraulic gradient across the transect. The average horizontal hydraulic gradient for the transect in August 2003 was calculated between wells T-20 and R-10 and is approximately 0.003 foot/foot. Table D-3a presents matrices of the subarea hydraulic conductivity, subarea dimensions, and calculated areas, and Table D-3b presents calculated specific discharge and volumetric flow rates of each subarea for August 2003. Table D-3c presents matrices of the subarea hydraulic conductivity, subarea dimensions, and calculated areas, and Table D-3d presents calculated specific discharge and volumetric flow rates of each subarea for the high water level condition.

As indicated by the matrices in Table D-3b, the specific discharge for all material types in the alluvium ranges from approximately 0.067 to 0.450 ft/d for the given hydraulic gradient. Since the hydraulic conductivity of the Friars formation is estimated to be 1 ft/d, the specific discharge for these subareas is 0.003 ft/d. The total volumetric flow through the cross sectional area is approximately 88 gpm; this value is approximately 11 percent less than estimated groundwater extraction rates at the nearby groundwater extraction system. This relatively small difference in flow at the two locations suggests that the flow estimated from empirical values of hydraulic conductivity and water level measurements is reasonable, and that mass removal at the extraction system can be used to calibrate or constrain the transect mass flux estimates for the August 2003 baseline condition.

As indicated in Table D-3d, the specific discharge in the future re-saturated vadose zone materials ranges from 0.0001 ft/d to 0.288 ft/day for the assigned hydraulic conductivities. Total flow across the transect for this condition is approximately 90 gpm; this small (2 gpm) increase in total flow is expected, since the re-saturated materials have low estimated hydraulic conductivity compared to underlying saturated materials.

Assignment of Average Concentrations Across the Transect and Equivalent Source Terms for Groundwater in Contact with LNAPL

Figures D-4 and D-5 present the concentrations and concentration distributions in cross section along the transect for MTBE and benzene, respectively. The concentrations and concentration distribution of each constituent in vertical cross section were assigned for each subarea by interpretation of August 2003 isoconcentration maps, plume cross sections parallel to the direction of groundwater flow, vertical cross-sectional interpolations of the analytical data orthogonal to flow, and assumptions regarding equivalent source term concentrations in the presence of LNAPL. In addition, the distributions were based on consideration of the lithology and assumptions regarding the mixing depth or vertical dispersion of soluble constituents from the LNAPL. Considerations were made to account for the vertically integrated nature of the samples collected from monitoring wells with longer well screens. The average MTBE and benzene concentrations within each subarea were calculated as the geometric mean of the values of each isoconcentration contour lying within the subarea. For subareas that included monitoring wells, the geometric mean calculation included the analytical data.

Use of the interpolation methods described above can underestimate the expected concentrations (and associated mass flux) of dissolved petroleum constituents in groundwater that is in contact with and/or adjacent to LNAPL. To address this concern, equivalent dissolved concentrations in equilibrium with LNAPL were estimated and were assigned to subareas of the transect where an LIF response indicated the presence of residual LNAPL. These equivalent source term concentrations represent the effective solubility of each constituent, which is defined as the product of the pure phase component solubility and the mass fraction or mole fraction of each constituent in the petroleum hydrocarbon mixture.

Equivalent source term concentrations were estimated using constituent composition data obtained from analysis of LNAPL samples from monitoring wells R-9, R-10, T-3, T-4, and T-18. The weight percent of MTBE and benzene in LNAPL samples from these wells ranged from <0.01 to 0.04 percent, and from 0.02 to 2.2 percent, respectively (Equilon Enterprises LLC and Aqui-Ver, Inc. 2001). The maximum weight percent value of each constituent was found in the LNAPL sample collected from well R-9. These values were multiplied by the pure component solubility to estimate equilibrium dissolved-phase concentrations for MTBE and benzene of approximately 20,000 μg/l and 39,600 μg/l, respectively. This approach assumes the weight percent values are equivalent to mole fraction, and is a conservative approach because it is the highest concentration possible based on the assumption that equilibrium dissolution occurs. These values are similar to maximum concentrations detected in groundwater samples collected from some the property boundary transect monitoring wells and other on- and off-site monitoring wells, but are significantly greater than concentrations typically collected from most monitoring wells in the off-site areas near to and downgradient of the LNAPL-affected zone.

The thickness and areal dimensions of groundwater in contact with LNAPL for both water level conditions were estimated from the interpretations of the LIF data. For the August 2003 water level condition, groundwater intersects the inferred extent of residual LNAPL across approximately 345 feet of the transect. This includes an area extending from approximately well R-43 AS/AD to well R-9, and an additional 40 feet in the vicinity of well R-10. The LIF response data indicates groundwater contacts residual LNAPL over a depth of approximately 1 foot, therefore, the uppermost subarea of the transect was assigned a thickness of 1 foot. Equivalent source term concentrations, or effective solubility values, were assigned these subareas. For the high water level condition, an additional 4 feet above this LNAPL-affected area was assigned the effective solubility values to represent the additional areas where groundwater is likely to contact residual LNAPL in soil after remedial groundwater extraction is discontinued. Tables D-4a and D-4b present the assigned concentrations in each subarea for August 2003 and the high water level condition, respectively.

D-3.3 Results

Tables D-5a and D-5b present the calculated mass flux of MTBE and benzene for August 2003 and the mass flux for the future high water level condition, respectively. Tables D-5c and D-5d present target concentrations, concentration distributions, and associated target mass fluxes for each condition, respectively. These values were obtained by reducing the concentration in each cell by a uniform factor equal to the desired mass flux reduction. Table D-6 presents a summary of the transect mass flux evaluation, and includes details for both conditions regarding the contribution of the mass flux from subareas in contact with residual LNAPL, target effective solubility values, target mole fractions, and reduction factors associated with the target mole fractions. These details are discussed below.

LNAPL Boundary August 2003 Mass Flux

As presented in Tables D-5a and Table D-6, the total MTBE and benzene mass fluxes at the transect in August 2003 are approximately 133 g/d and 241 g/d, respectively. Table D-5a includes a comparison to the extraction system mass removal rates in August 2003, which were calculated from system flow rates and average influent concentrations. The transect mass flux and system mass removal rates correspond reasonably well. The estimated MTBE mass flux of 133 g/d is approximately 3 percent less than the extraction system mass removal of 137 g/d, and the estimated benzene mass flux of 241 g/d is approximately 13 percent less than the extraction system mass removal of 278 g/d.

As indicated in Table D-6, the current mass flux from the subareas representing groundwater in contact with LNAPL is approximately 32 percent for MTBE, and approximately 35 percent for benzene.

LNAPL Boundary High Water Level Condition Mass Flux

The future high water level condition results in increased MTBE and benzene mass fluxes of 257 g/d and 486 g/d, respectively, as presented in Tables D-5b and D-6. Since a greater cross-sectional area of groundwater is in contact with LNAPL, the mass flux from these subareas contributes approximately 65 percent of the total mass flux of MTBE, and approximately 68 percent of the total mass flux of benzene. The MTBE mass flux for this condition is approximately 53 times greater than the target MTBE mass flux of 5 g/d. The benzene mass flux for this condition is approximately 455 times greater than the target of 1 g/d.

Target Concentration and Mole Fraction

Subarea concentrations for the high water level condition, including the subareas representing effective solubility from LNAPL, were reduced by the appropriate factor (53 for MTBE and 455 for benzene) to obtain concentrations that would result in the target mass flux. As presented in Table D-6, the resulting target concentrations for groundwater in contact with residual LNAPL, which represent target effective solubility values for each constituent, are 385 μg/l for MTBE and 87 μg/l for benzene. Corresponding target mole fractions are 7.6×10^{-6} for MTBE and 4.8×10^{-5} for benzene.

D-4.0 SENSITIVITY AND UNCERTAINTY OF EMPIRICAL MASS FLUX ESTIMATES

Although the mass flux evaluations using the transect method allow for an improved understanding of the concentration distribution across a plume, the underlying assumptions and data required impart a degree of uncertainty in the resulting mass flux estimate. Uncertainties associated with estimates of the groundwater discharge, interpolations of the concentration distribution, and equivalent source term concentrations result in uncertainties of the calculated mass flux estimates. Where uncertain, conservative values and assumptions were used in this evaluation.

Uncertainties Related to Specific Discharge Estimates

Groundwater discharge is calculated from estimates of hydraulic conductivity and hydraulic gradient. Although some error is associated with hand-measurement of water levels, and therefore calculated hydraulic gradients, estimates of groundwater discharge are much more sensitive to hydraulic conductivity values. Values of hydraulic conductivity in the alluvium at the Mission Valley Terminal off-site areas were assigned based on indicator kriging, an unbiased statistical interpolation of data distributions. The initial values of hydraulic conductivity were obtained from interpretations of lithology and aquifer test data. This approach reduces much of the bias in the interpretation of aquifer hydraulic parameters; however, the assigned values of hydraulic conductivity may deviate from actual values. This is also true for the re-saturated vadose zone soils where hydraulic conductivity was estimated from permeability testing of soil cores. In general, the range of deviation is expected to be within a factor of two for a given material type, and therefore provides a reasonable estimate of the groundwater discharge.

Uncertainties Related to Monitoring Well Coverage of the Transect

Calculated mass flux values are also sensitive to the monitoring network configuration including sample or well screen intervals and sample point density, which affect the resulting spatial and temporal interpolations of the concentration distributions. The horizontal and vertical extent of the plume at the LNAPL boundary were interpolated based on analytical sample results for wells screened across the depth of the shallow alluvium, and one well screened over a small interval in the deep alluvium. The vertical distribution of the plume across the transect was defined based on the vertical distribution of the off-site plume as interpolated with samples from the cluster well monitoring network, using an assumed low degree of vertical mixing or dispersion.

There is a linear relationship between the calculated mass flux, the estimated specific discharge, and the interpolated concentration distribution. If the hydraulic conductivity is doubled or halved, the specific discharge, and therefore the mass flux, is doubled or halved. Likewise, if the concentrations vary by a factor of two, the calculated mass fluxes vary accordingly. Overall, it is likely that the hydraulic conductivity and the analytical results vary by less than a factor of two, which results in an uncertainty in the results by +/- a factor of five. Additional assumptions associated with the constituent concentrations in the presence of LNAPL also add uncertainty to the mass flux estimates, as discussed below.

Uncertainties in the Equivalent Source Term

Use of estimated equivalent source term strength introduces uncertainty in the estimated mass flux. Uncertainty is introduced in the assumed distribution of LNAPL in the subsurface; the equivalent dissolved phase concentration of MTBE and benzene, and the thickness and area of groundwater that is in assumed equilibrium concentrations with the LNAPL. To be conservative, this analysis assumed that LNAPL was distributed uniformly over the portion of the transect where LNAPL has historically been measured, and where an LIF response indicated the presence of residual LNAPL. In reality, it is more likely that the LNAPL distribution is discontinuous over these regions.

Also, the actual vertical thickness of groundwater in contact with the LNAPL is not well known and may vary from inches to several feet depending on local sediment and flow characteristics. Conservative assumptions were used in assigning the vertical saturated thickness over which to apply the equivalent source term concentrations for the mass flux calculations.

D-5.0 EVALUATION OF LNAPL DEPLETION AND ATTAINMENT OF MASS FLUX TARGETS

An evaluation of the timeframe to achieve the target level of depletion of the submerged residual LNAPL was performed. The objective was to evaluate the time required to achieve concentrations in groundwater in contact with the residual LNAPL zone (target effective solubility values) and corresponding target mole fractions.

An analytical model was used to evaluate timeframes for two representative sequences of LNAPL-affected soils. The software utility LNAST (LNAPL Dissolution and Transport Screening Tool) contains analytical solutions that describe the principles of LNAPL distribution, dissolution, and volatilization in the subsurface (API 2001).

Many simplifying assumptions are inherent in analytical solutions: therefore, the calculations do not provide a detailed representation of the site. The evaluation of LNAPL depletion for this evaluation is designed to provide a conservative estimate of the timeframe to achieve mass flux targets. The results of the calculations cannot be precisely calibrated to site conditions; however, applied conservatism in the approach allows for a quantitative conceptual model of site conditions that can be used for remedial decision making.

LNAST allows the user to specify LNAPL conditions (e.g., saturation and spatial distribution) in the water table region for a simplified layered soil condition. For this evaluation, the LNAPL conditions in the water table region are simulated to deplete under specified ambient conditions (i.e., no remediation influence). The specified distribution of LNAPL controls the dissolution of hydrocarbon constituents from the LNAPL into the groundwater and vapor phases. Initial mole fractions of MTBE and benzene from site-specific LNAPL composition samples were assigned, and the concentrations of these constituents in groundwater from the LNAPL source zone were calculated over time. Biodegradation within the LNAPL-affected source zone is not considered in LNAST.

LNAST uses the source zone dimensions and properties assigned by the user to define a conceptual model consisting of a vertical interval from the top of the oil capillary fringe to the lowermost occurrence of LNAPL in the soil column. This includes:

(1) the interval from the top of the oil capillary fringe to the oil/air interface, where oil, water and air co-exist in the pore space;

(2) the interval from the oil/air interface to the oil/water interface, where oil and water coexist in the pore space and the oil may have significant mobility; and

(3) the zone below the oil/water interface, where immobile oil may be trapped at residual saturation due to a rise in the water table.

The LNAPL source zone is simplified as a rectangular box through which groundwater flows in contact with prescribed vertical saturation of LNAPL. Mass balance is accounted for in the partitioning from the LNAPL source to the water and vapor phases – that is, the total LNAPL mass as well as that of each of the soluble constituents within the LNAPL is recalculated for each time step. However, as mass is depleted from the LNAPL through dissolution and volatilization, the distribution (saturation) of the LNAPL is not recalculated from the initial condition, nor is the groundwater flux through the source zone re-calculated as the zone is depleted of LNAPL. Therefore, while the method considers relatively complicated multiphase and multi-component depletion, the conceptual model represents only a simplified version of a much more complicated system. The intended use of the LNAST results is to estimate an approximate range of depletion timeframes using some site-specific data.

Tables D-7 and D-8 present the LNAST input for each scenario, which are referred to as "Soil Column 1" and "Soil Column 2," respectively. Each Soil Column consists of three layers consisting of saturated well-graded sands (SW), capillary-fringe clayey silts (MH), and vadose-zone silty sands (SM). The differences between the soil columns are the position of the water table and the residual LNAPL saturation distribution. Each LNAPL saturation distribution is consistent with and based on soil profiles evaluated in the total mass estimates in this report (Appendix C). The saturation distributions were estimated from ratios of the volume of LNAPL to the total LNAPL-affected soil volume; these volumes were estimated from LNAPL mass and assumed density of LNAPL and bulk density of soil. Soil Column 2 represents a more conservative condition that will take longer to deplete than Soil Column 1.

The source area dimensions were conservatively assigned. The length of LNAPL source zone extends from the Terminal property boundary to the downgradient edge of LNAPL-affected areas as interpreted from LIF response data, and the width of LNAPL-affected area used is consistent with the width used in the mass flux evaluation.

Soil properties and LNAPL properties were assigned LNAST default values for particular soil types, with the exception of the mole fractions of MTBE and benzene, which were assigned as the maximum mole fractions estimated from the site-specific LNAPL composition results (Equilon Enterprises LLC and Aqui-Ver, Inc. 2001).

Figures D-6 and D-7 present the predicted concentrations of MTBE and benzene in the vicinity of the LNAPL source zone as a function of time for Soil Column 1 and Soil Column 2, respectively. For Soil Column 1, the estimated time to achieve target concentrations in the vicinity of the LNAPL source (target effective solubility) for MTBE is approximately 1.7 years. Benzene in Soil Column 1 reaches the target effective solubility in approximately 58 years. For Soil Column 2, the results indicate much longer timeframes to meet target effective solubility for both MTBE and benzene, with targets being met at approximately 20 to 30 years for MTBE, and approximately 500 years for benzene, if the model-calculated trend is extrapolated down to the target concentration line.

Differences in the timeframes calculated by LNAST for the two soil columns are a function of the greater degree of LNAPL saturation given for Soil Column 2, and the location of the water level relative to the clayey silt layer. For Soil Column 2, more residual LNAPL is “trapped” within the tighter material, and takes much longer to deplete under ambient conditions.

D-6.0 REFERENCES

American Petroleum Institute (API). 2001. *Evaluating Hydrocarbon Removal From Source Zones: Tools to Assess Concentration Reduction.* A Report Submitted to: The American Petroleum Institute. Draft. January.

_____. 2003a. *Answers to Frequently Asked Questions About Managing Risk at LNAPL Sites.* API Soil and Groundwater Research Bulletin Number 18. API Soil and Groundwater Technical Task Force. May.

_____. 2003b. *Estimating Mass Flux for Decision-Making: An Expert Workshop.* API Soil and Groundwater Research Bulletin, In Press. API Soil and Groundwater Technical Task Force.

Boyle Engineering Corporation. 1995. Reservoir Management Study. Report submitted to the City of San Diego Water Department.

CH2Mhill. 2003. San Diego River System Conceptual Groundwater Management Plan. Prepared for City of San Diego. May.

Equilon Enterprises LLC and Aqui-Ver, Inc. 2001. Conceptual Site Model Report, Equilon Mission Valley and San Diego Terminals, 9950 San Diego Mission Road, San Diego, California. November.

LFR Levine·Fricke (LFR). 2003a. Quarterly Groundwater Monitoring Report, Third Quarter of 2003, Mission Valley Terminal, San Diego, California. October.

_____. 2003b. Additional LNAPL Distribution and Lithologic Characterization, Mission Valley Terminal, 9950 and 9966 San Diego Mission Road, San Diego, California. December 12.

Table D-1
Mass Flux Targets for MTBE and Benzene in Groundwater
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

Potential mass flux based on variable supply well pumping and California Water Quality Criteria, grams/day:

	Criteria, ug/L:		
	MTBE CA Primary	MTBE CA Secondary	Benzene MCL
Potential Supply Well Pumping Rate (gpm)	13	5	1
35	2.5	1.0	0.2
50	3.5	1.4	0.3
75	5.3	2.0	0.4
100	7.1	2.7	0.5
125	8.9	3.4	0.7
150	10.6	4.1	0.8
175	12.4	4.8	1.0
188 [1]	13.3	5.1	1.0
200	14.2	5.5	1.1
250	17.7	6.8	1.4
300	21.3	8.2	1.6
350	24.8	9.5	1.9
400	28.3	10.9	2.2
450	31.9	12.3	2.5
500	35.4	13.6	2.7
550	39.0	15.0	3.0
600	42.5	16.4	3.3
650	46.1	17.7	3.5
700	49.6	19.1	3.8
750	53.1	20.4	4.1
800	56.7	21.8	4.4
850	60.2	23.2	4.6
900	63.8	24.5	4.9
950	67.3	25.9	5.2
1000	70.9	27.3	5.5

Notes:

[1] Potential supply well pumping rate for one of eight individual supply wells recommended in the City of San Diego's "Reservoir Management Study" (Boyle Engineering 1995).

μg/l = micrograms per liter
gpm = gallons per minute

Table D-2
Transect Monitoring Well Construction Details and August 2003 Empirical Data
Mission Valley Terminal, San Diego, CA
LFR 002-10180-13

	Well Construction:							Empirical Data:		
Transect Wells	**Top of Casing Elevation** (feet-msl)	**Top of Screen Depth** (feet)	**Bottom of Screen Depth** (feet)	**Total Well Depth** (feet)	**Top of Screen Elevation** (feet-msl)	**Bottom of Screen Elevation** (feet-msl)	**Total Depth of Well Elevation** (feet-msl)	**Ground-water Elevation** (feet-msl)	**MTBE** (ug/L)	**Benzene** (ug/L)
R-43AS	68.89	25.0	40.0	41.00	43.89	28.89	27.89	40.08	12,000	5,900
R-43AD	69.17	61.0	66.0	67.00	8.17	3.17	2.17	39.91	210	<0.5
R-9	64.39	8.6	28.6	28.60	55.79	35.79	35.79	40.86	5,700	29,000
R-10	60.90	9.0	29.0	29.00	51.90	31.90	31.90	41.91	600	6,000
R-18	55.72	7.0	27.0	27.35	48.72	28.72	28.37	45.07	2.0	<0.5

Table D-3a
HYDRAULIC CONDUCTIVITY AND AREA - NAPL Boundary Transect
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

HYDRAULIC CONDUCTIVITY (feet/day)[1]:

Distance (feet)[2]: 0 — 1600
Elevation: 42 ft msl

Elevation																			
41	50	50	50	50	50	72.1	50	86.6	86.6	150	150	86.6	86.6	86.6	50	10	22.4	50	50
37	50	50	50	50	50	72.1	50	86.6	86.6	150	150	86.6	86.6	86.6	50	10	22.4	50	50
25	10	10	10	10	10	50	50	50	50	150	150	150	86.6	86.6	50	10	10	150	150
10	22.4	22.4	22.4	22.4	50	104.0	150	86.6	86.6	150	150	150	42.2	42.2	22.4	10	22.4	150	150
-1	50	50	50	50	50	86.6	150	86.6	86.6	150	150	150	86.6	86.6	50	50	22.4	150	150
-8	7.1	7.1	7.1	7.1	7.1	150	150	86.6	86.6	86.6	86.6	12.2	7.1	7.1	1	1	7.9	1	1
-40	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

- 40 ft msl

AREA (ft²)[3]:

Length (feet) \ Width (feet):	125	55	115	10	115	100	35	45	70	90	40	85	55	60	160	85	70	205	80
1	125	55	115	10	115	100	35	45	70	90	40	85	55	60	160	85	70	205	80
4	500	220	460	40	460	400	140	180	280	360	160	340	220	240	640	340	280	820	320
12	1500	660	1380	120	1380	1200	420	540	840	1080	480	1020	660	720	1920	1020	840	2460	960
15	1875	825	1725	150	1725	1500	525	675	1050	1350	600	1275	825	900	2400	1275	1050	3075	1200
11	1375	605	1265	110	1265	1100	385	495	770	990	440	935	605	660	1760	935	770	2255	880
7	875	385	805	70	805	700	245	315	490	630	280	595	385	420	1120	595	490	1435	560
32	4000	1760	3680	320	3680	3200	1120	1440	2240	2880	1280	2720	1760	1920	5120	2720	2240	6560	2560

Cumulative Length Across Transect:

0 125 180 295 305 420 520 555 600 670 760 800 885 940 1000 1160 1245 1315 1520 1600

NOTES:

[1] Hydraulic conductivity values assigned for each subarea were determined from the indicator kriging analysis.

[2] Horizontal distance across the transect.

[3] Subarea cell dimensions are based on the hydraulic conductivity distribution and were refined by evaluating the distribution of the dissolved-phase plume in cross-section.

= Zone of High Hydraulic Conductivity

= Zone of NAPL/Water Contact

Table D-3b
SPECIFIC DISCHARGE CALCULATION - NAPL Boundary Transect
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

Discharge, ft/day[1]
August 2003 dh/dx: **0.003**

69 ft msl	**0**																		**1600**
1	0.150	0.150	0.150	0.150	0.150	0.216	0.150	0.260	0.260	0.450	0.450	0.260	0.260	0.260	0.150	0.030	0.067	0.150	0.150
4	0.150	0.150	0.150	0.150	0.150	0.216	0.150	0.260	0.260	0.450	0.450	0.260	0.260	0.260	0.150	0.030	0.067	0.150	0.150
12	0.030	0.030	0.030	0.030	0.030	0.150	0.150	0.150	0.150	0.450	0.450	0.450	0.260	0.260	0.150	0.030	0.030	0.450	0.450
15	0.067	0.067	0.067	0.067	0.150	0.312	0.450	0.260	0.260	0.450	0.450	0.450	0.127	0.127	0.067	0.030	0.067	0.450	0.450
11	0.150	0.150	0.150	0.150	0.150	0.260	0.450	0.260	0.260	0.450	0.450	0.450	0.260	0.260	0.150	0.150	0.067	0.450	0.450
7	0.021	0.021	0.021	0.021	0.021	0.450	0.450	0.260	0.260	0.260	0.260	0.037	0.021	0.021	0.003	0.003	0.024	0.003	0.003
32	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
- 40 ft msl																			

Darcy Flow, ft^3/day
August 2003 dh/dx:

69 ft msl	**0**																		**1600**
1	18.750	8.250	17.250	1.500	17.250	21.634	5.250	11.691	18.187	40.500	18.000	22.084	14.289	15.588	24.000	2.550	4.696	30.750	12.000
4	75.000	33.000	69.000	6.000	69.000	86.535	21.000	46.765	72.746	162.000	72.000	88.335	57.158	62.354	96.000	10.200	18.783	123.000	48.000
12	45.000	19.800	41.400	3.600	41.400	180.000	63.000	81.000	126.000	486.000	216.000	459.000	171.473	187.061	288.000	30.600	25.200	1107.000	432.000
15	125.779	55.343	115.717	10.062	258.750	468.019	236.250	175.370	272.798	607.500	270.000	573.750	104.375	113.863	160.997	38.250	70.436	1383.750	540.000
11	206.250	90.750	189.750	16.500	189.750	285.788	173.250	128.605	200.052	445.500	198.000	420.750	157.184	171.473	264.000	140.250	51.653	1014.750	396.000
7	18.562	8.167	17.077	1.485	17.077	315.000	110.250	81.839	127.306	163.679	72.746	21.862	8.167	8.910	3.360	1.785	11.667	4.305	1.680
32	12.000	5.280	11.040	0.960	11.040	9.600	3.360	4.320	6.720	8.640	3.840	8.160	5.280	5.760	15.360	8.160	6.720	19.680	7.680
- 40 ft msl																			
Total Q in each Subarea:	501.340	220.590	461.233	40.107	604.267	1366.576	612.360	529.591	823.808	1913.819	850.586	1593.940	517.926	565.010	851.717	231.795	189.155	3683.235	1437.360

Total through Transect (ft^3/day):	**16994**
Total through Transect (gpm):	**88**
System Flow (gpm):	**99**
Percent difference from system rate:	**11%**
(system flow is 11% greater than transect)	

NOTES:
[1] Specific discharge for each subarea is calculated from the subarea hydraulic conductivity and the hydraulic gradient for that date.
[2] Hydraulic gradient calculated with groundwater elevations from well T-20 and R-10 for each date.

= Zone of NAPL/Water Contact

Table D-3c.
HYDRAULIC CONDUCTIVITY AND AREA - NAPL Boundary Transect - Flooded Conditions
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

HYDRAULIC CONDUCTIVITY (feet/day)[1]:

Distance (feet)[2]: 0 to 1600
Elevation: 46 ft msl

Elevation																			
46	4	4	4	4	4	11.5	4	19.6	19.6	96	96	19.6	19.6	19.6	4	0.017	0.3	4	4
42	50	50	50	50	50	72.1	50	86.6	86.6	150	150	86.6	86.6	86.6	50	10	22.4	50	50
37	50	50	50	50	50	72.1	50	86.6	86.6	150	150	86.6	86.6	86.6	50	10	22.4	50	50
25	10	10	10	10	10	50	50	50	50	150	150	150	86.6	86.6	50	10	10	150	150
10	22.4	22.4	22.4	22.4	50	104.0	150	86.6	86.6	150	150	150	42.2	42.2	22.4	10	22.4	150	150
-1	50	50	50	50	50	86.6	150	86.6	86.6	150	150	150	86.6	86.6	50	50	22.4	150	150
-8	7.1	7.1	7.1	7.1	7.1	150	150	86.6	86.6	86.6	86.6	12.2	7.1	7.1	1	1	7.9	1	1
-40	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

- 40 ft msl

AREA (ft²)[3]:

Length (Depth below WT) (feet) \ Width (feet):	125	55	115	10	115	100	35	45	70	90	40	85	55	60	160	85	70	205	80
4	500	220	460	40	460	400	140	180	280	360	160	340	220	240	640	340	280	820	320
1	125	55	115	10	115	100	35	45	70	90	40	85	55	60	160	85	70	205	80
4	500	220	460	40	460	400	140	180	280	360	160	340	220	240	640	340	280	820	320
12	1500	660	1380	120	1380	1200	420	540	840	1080	480	1020	660	720	1920	1020	840	2460	960
15	1875	825	1725	150	1725	1500	525	675	1050	1350	600	1275	825	900	2400	1275	1050	3075	1200
11	1375	605	1265	110	1265	1100	385	495	770	990	440	935	605	660	1760	935	770	2255	880
7	875	385	805	70	805	700	245	315	490	630	280	595	385	420	1120	595	490	1435	560
32	4000	1760	3680	320	3680	3200	1120	1440	2240	2880	1280	2720	1760	1920	5120	2720	2240	6560	2560

Cumulative Length Across Transect:

0	125	180	295	305	420	520	555	600	670	760	800	885	940	1000	1160	1245	1315	1520	1600

NOTES:

[1] Hydraulic conductivity values assigned for each subarea were determined from the indicator kriging analysis.
[2] Horizontal distance across the transect.
[3] Subarea cell dimensions are based on the hydraulic conductivity distribution and were refined by evaluating the distribution of the dissolved-phase plume in cross-section.

= Zone of High Hydraulic Conductivity

= Zone of NAPL/Water Contact

= Flooded Vadose Soils

Table D-3d
FLOW CALCULATIONS- NAPL Boundary Transect - Flooded Conditions
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

Discharge, ft/day[1]
Flooded: **0.003**

48 ft msl	0																		1600
4	0.012	0.012	0.012	0.012	0.012	0.035	0.012	0.059	0.059	0.288	0.288	0.059	0.059	0.059	0.012	0.000	0.001	0.012	0.012
1	0.150	0.150	0.150	0.150	0.150	0.216	0.150	0.260	0.260	0.450	0.450	0.260	0.260	0.260	0.150	0.030	0.067	0.150	0.150
4	0.150	0.150	0.150	0.150	0.150	0.216	0.150	0.260	0.260	0.450	0.450	0.260	0.260	0.260	0.150	0.030	0.067	0.150	0.150
12	0.030	0.030	0.030	0.030	0.030	0.150	0.150	0.150	0.150	0.450	0.450	0.450	0.260	0.260	0.150	0.030	0.030	0.450	0.450
15	0.067	0.067	0.067	0.067	0.150	0.312	0.450	0.260	0.260	0.450	0.450	0.450	0.127	0.127	0.067	0.030	0.067	0.450	0.450
11	0.150	0.150	0.150	0.150	0.150	0.260	0.450	0.260	0.260	0.450	0.450	0.450	0.260	0.260	0.150	0.150	0.067	0.450	0.450
7	0.021	0.021	0.021	0.021	0.021	0.450	0.450	0.260	0.260	0.260	0.260	0.037	0.021	0.021	0.003	0.003	0.024	0.003	0.003
32	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003

Darcy Flow, ft^3/day
Flooded: **0.003**

48 ft msl	0																		1600
4	6.000	2.640	5.520	0.480	5.520	13.846	1.680	10.582	16.461	103.680	46.080	19.988	12.933	14.109	7.680	0.017	0.219	9.840	3.840
1	18.750	8.250	17.250	1.500	17.250	21.634	5.250	11.691	18.187	40.500	18.000	22.084	14.289	15.588	24.000	2.550	4.696	30.750	12.000
4	75.000	33.000	69.000	6.000	69.000	86.535	21.000	46.765	72.746	162.000	72.000	88.335	57.158	62.354	96.000	10.200	18.783	123.000	48.000
12	45.000	19.800	41.400	3.600	41.400	180.000	63.000	81.000	126.000	486.000	216.000	459.000	171.473	187.061	288.000	30.600	25.200	1107.000	432.000
15	125.779	55.343	115.717	10.062	258.750	468.019	236.250	175.370	272.798	607.500	270.000	573.750	104.375	113.863	160.997	38.250	70.436	1383.750	540.000
11	206.250	90.750	189.750	16.500	189.750	285.788	173.250	128.605	200.052	445.500	198.000	420.750	157.184	171.473	264.000	140.250	51.653	1014.750	396.000
7	18.562	8.167	17.077	1.485	17.077	315.000	110.250	81.839	127.306	163.679	72.746	21.862	8.167	8.910	3.360	1.785	11.667	4.305	1.680
32	12.000	5.280	11.040	0.960	11.040	9.600	3.360	4.320	6.720	8.640	3.840	8.160	5.280	5.760	15.360	8.160	6.720	19.680	7.680
Total Q in each Subarea:	507.3	223.2	466.8	40.6	609.8	1380.4	614.0	540.2	840.3	2017.5	896.7	1613.9	530.9	579.1	859.4	231.8	189.4	3693.1	1441.2

Total through Transect (ft^3/day): **17276**
Total through Transect (gpm): **90**
System Flow (gpm): **99**

NOTES:
[1] Specific discharge for each subarea is calculated from the subarea hydraulic conductivity and the hydraulic gradient for that date.
[2] Hydraulic gradient calculated with groundwater elevations from well T-20 and R-10 for each date.

= Zone of NAPL/Water Contact

= Flooded Vadose Soils

Table D-4a
CONCENTRATION DISTRIBUTIONS IN CROSS SECTION - NAPL Boundary Transect
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

MTBE Concentration, ug/L [1]
August 2003:

Concentration, ug/L																			
42 ft msl	**0**																		**1200**
1	0	10	1000	20000	20000	20000	20000	20000	829	391	20000	100	32	10	3	3	3	2	0
4	0	10	1000	4932	2387	2387	2387	2387	829	391	391	100	32	10	3	3	3	2	0
12	0	10	316	4932	2387	2387	2387	829	829	157	157	100	10	10	3	3	3	2	0
15	0	5	316	1000	829	829	829	316	316	100	100	10	10	3	3	3	2	2	0
11	0	5	32	120	120	316	100	100	100	32	32	3	3	3	2	2	0	0	0
7	0	2	10	32	32	32	32	32	32	10	10	3	3	2	2	0	0	0	0
32	0	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0
- 40 ft msl																			

Benzene Concentration, ug/L [1]
August 2003:

Concentration, ug/L																			
42 ft msl	**0**																		**1200**
1	0	10	513	39600	39600	39600	39600	39600	2449	2449	39600	278	5	0	0	0	0	0	0
4	0	10	513	3283	3283	2449	2449	6459	2449	2449	2449	278	2	0	0	0	0	0	0
12	0	5	181	3283	3283	2449	2449	2449	2449	2449	278	38	0	0	0	0	0	0	0
15	0	2	78	181	181	843	843	843	843	278	38	5	0	0	0	0	0	0	0
11	0	0	0	5	5	14	14	32	32	5	2	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- 40 ft msl																			

NOTES:

[1] The concentration of each constituent in each subarea is calculated as the geometric mean of the values associated with each contour interval passing through the subarea. For subareas that correspond to well screen intervals with analytical data, the actual value is assigned. See text for a more detailed explanation of the criteria.

= Zone of NAPL/Water Contact

Table D-4b
CONCENTRATION DISTRIBUTIONS IN CROSS SECTION - NAPL Boundary Transect - Flooded Conditions
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

MTBE Concentration, ug/L [1]

Flooded:

Concentration, ug/L																			
48 ft msl	0																		1200
4	0	10	1000	20000	20000	20000	20000	20000	20000	20000	20000	20000	32	10	3	3	3	2	0
1	0	10	1000	20000	20000	20000	20000	20000	829	391	20000	100	32	10	3	3	3	2	0
4	0	10	1000	4932	2387	2387	2387	2387	829	391	391	100	32	10	3	3	3	2	0
12	0	10	316	4932	2387	2387	2387	829	829	157	157	100	10	10	3	3	3	2	0
15	0	5	316	1000	829	829	829	316	316	100	100	10	10	3	3	3	2	2	0
11	0	5	32	120	120	316	100	100	100	32	32	3	3	3	2	2	0	0	0
7	0	2	10	32	32	32	32	32	32	10	10	3	3	2	2	0	0	0	0
32	0	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0
- 40 ft msl																			

Benzene Concentration, ug/L [1]

Flooded:

Concentration, ug/L																			
48 ft msl	0																		1200
4	0	10	513	39600	39600	39600	39600	39600	39600	39600	39600	39600	5	0	0	0	0	0	0
1	0	10	513	39600	39600	39600	39600	39600	2449	2449	39600	278	5	0	0	0	0	0	0
4	0	10	513	3283	3283	2449	2449	6459	2449	2449	2449	278	2	0	0	0	0	0	0
12	0	5	181	3283	3283	2449	2449	2449	2449	2449	278	38	0	0	0	0	0	0	0
15	0	2	78	181	181	843	843	843	843	278	38	5	0	0	0	0	0	0	0
11	0	0	0	5	5	14	14	32	32	5	2	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NOTES:

[1] The concentration of each constituent in each subarea is calculated as the geometric mean of the values associated with each contour interval passing through the subarea. For subareas that correspond to well screen intervals with analytical data, the actual value is assigned. See text for a more detailed explanation of the criteria.

= Zone of NAPL/Water Contact

= Flooded Vadose Soils

Table D-5a
MASS FLUX CALCULATIONS - NAPL Boundary Transect
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

MTBE Mass Flux, grams/day[1]:
August 2003:

69 ft msl	**0**																		**1200**
1	0.0000	0.0023	0.4885	0.8496	9.7704	12.2534	2.9736	6.6220	0.4270	0.4490	10.1952	0.0625	0.0128	0.0044	0.0021	0.0002	0.0004	0.0015	0.0000
4	0.0000	0.0093	1.9541	0.8381	4.6653	5.8509	1.4199	3.1620	1.7082	1.7961	0.7983	0.2502	0.0512	0.0177	0.0086	0.0009	0.0017	0.0062	0.0000
12	0.0000	0.0056	0.3708	0.5029	2.7992	12.1704	4.2596	1.9020	2.9586	2.1541	0.9574	1.2999	0.0486	0.0530	0.0258	0.0027	0.0023	0.0557	0.0000
15	0.0000	0.0074	1.0363	0.2850	6.0757	10.9896	5.5474	1.5705	2.4431	1.7204	0.7646	0.1625	0.0296	0.0102	0.0144	0.0034	0.0034	0.0670	0.0000
11	0.0000	0.0122	0.1699	0.0563	0.6469	2.5594	0.4906	0.3642	0.5665	0.3990	0.1773	0.0377	0.0141	0.0154	0.0128	0.0068	0.0000	0.0000	0.0000
7	0.0000	0.0004	0.0048	0.0013	0.0153	0.2821	0.0987	0.0733	0.1140	0.0464	0.0206	0.0020	0.0007	0.0004	0.0002	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0003	0.0005	0.0000	0.0005	0.0005	0.0002	0.0002	0.0003	0.0004	0.0002	0.0004	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
- 20 ft msl																			
Column Mass Flux (grams/day)[2]:	**0.00**	**0.04**	**4.02**	**2.53**	**23.97**	**44.11**	**14.79**	**13.69**	**8.22**	**6.57**	**12.91**	**1.82**	**0.16**	**0.10**	**0.06**	**0.01**	**0.01**	**0.13**	**0.00**
																		Total:[3]	**133**
percent of total:	0.0%	0.0%	3.0%	**1.9%**	**18.0%**	**33.1%**	**11.1%**	**10.3%**	**6.2%**	**4.9%**	**9.7%**	1.4%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%

Benzene Mass Flux, grams/day[1]:
August 2003:

69 ft msl	**0**																		**1200**
1	0.0000	0.0023	0.2504	1.6822	19.3454	24.2616	5.8877	13.1115	1.2616	2.8095	20.1865	0.1741	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0093	1.0017	0.5579	6.4162	6.0029	1.4568	8.5537	5.0464	11.2379	4.9946	0.6962	0.0028	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0027	0.2125	0.3348	3.8497	12.4865	4.3703	5.6189	8.7406	33.7136	1.7025	0.4937	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0027	0.2559	0.0516	1.3278	11.1791	5.6431	4.1889	6.5161	4.7883	0.2904	0.0768	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0022	0.0254	0.1117	0.0677	0.1152	0.1792	0.0597	0.0096	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
- 20 ft msl																			
Column Mass Flux (grams/day)[2]:	**0.00**	**0.02**	**1.72**	**2.63**	**30.96**	**54.04**	**17.43**	**31.59**	**21.74**	**52.61**	**27.18**	**1.44**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
																		Total:[3]	**241**
percent of total:	0.0%	0.0%	0.7%	1.1%	12.8%	**22.4%**	**7.2%**	**13.1%**	**9.0%**	**21.8%**	**11.3%**	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Summary:

Thickness of NAPL/Water Contact Zone:	MTBE Mass Flux	Percent Difference from System:	Benzene Mass Flux	Percent Difference from System:	System Removal - MTBE	System Removal - Benzene
1	**133**	**-3%**	**241**	**-13%**	**137**	**278**
1.5	152	11%	280	1%		
2	172	26%	319	15%		

NOTES:

[1] The mass flux for each subarea is calculated from the assigned specific discharge and concentration for each subarea and the subarea dimensions.

[2] The sum of the mass fluxes for each column in the cross-section.

[3] The total mass flux for each column in the transect; this value represents the mass discharge of MTBE through the entire plume width and depth.

= Zone of NAPL/Water Contact

Table D-5b.
MASS FLUX CALCULATIONS - NAPL Boundary Transect - Flooded Conditions
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

MTBE Mass Flux, grams/day[1]:
Flooded:

48 ft msl	0																		1200
4	0.000	0.001	0.156	0.272	3.127	7.842	0.952	5.994	9.323	58.724	26.100	11.321	0.012	0.004	0.001	0.000	0.000	0.000	0.000
1	0.000	0.002	0.489	0.850	9.770	12.253	2.974	6.622	0.427	0.449	10.195	0.063	0.013	0.004	0.002	0.000	0.000	0.002	0.000
4	0.000	0.009	1.954	0.838	4.665	5.851	1.420	3.162	1.708	1.796	0.798	0.250	0.051	0.018	0.009	0.001	0.002	0.006	0.000
12	0.000	0.006	0.371	0.503	2.799	12.170	4.260	1.902	2.959	2.154	0.957	1.300	0.049	0.053	0.026	0.003	0.002	0.056	0.000
15	0.000	0.007	1.036	0.285	6.076	10.990	5.547	1.571	2.443	1.720	0.765	0.162	0.030	0.010	0.014	0.003	0.003	0.067	0.000
11	0.000	0.012	0.170	0.056	0.647	2.559	0.491	0.364	0.567	0.399	0.177	0.038	0.014	0.015	0.013	0.007	0.000	0.000	0.000
7	0.000	0.000	0.005	0.001	0.015	0.282	0.099	0.073	0.114	0.046	0.021	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- 20 ft msl																			
Column Mass Flux (grams/day)[2]:	**0.00**	**0.04**	**4.18**	**2.81**	**27.10**	**51.95**	**15.74**	**19.69**	**17.54**	**65.29**	**39.01**	**13.14**	**0.17**	**0.11**	**0.06**	**0.01**	**0.01**	**0.13**	**0.00**
																		Total:[3]	**257**
percent of total:	0.0%	0.0%	1.6%	**1.1%**	**10.5%**	**20.2%**	**6.1%**	**7.7%**	**6.8%**	**25.4%**	**15.2%**	5.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%

Benzene Mass Flux, grams/day[1]:
Flooded:

48 ft msl	0																		1200
4	0.000	0.001	0.080	0.538	6.191	15.527	1.884	11.867	18.460	116.274	51.677	22.416	0.002	0.000	0.000	0.000	0.000	0.000	0.000
1	0.000	0.002	0.250	1.682	19.345	24.262	5.888	13.112	1.262	2.809	20.186	0.174	0.002	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.009	1.002	0.558	6.416	6.003	1.457	8.554	5.046	11.238	4.995	0.696	0.003	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.003	0.212	0.335	3.850	12.487	4.370	5.619	8.741	33.714	1.702	0.494	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.003	0.256	0.052	1.328	11.179	5.643	4.189	6.516	4.788	0.290	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.002	0.025	0.112	0.068	0.115	0.179	0.060	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- 20 ft msl																			
Column Mass Flux (grams/day)[2]:	**0.00**	**0.02**	**1.80**	**3.17**	**37.16**	**69.57**	**19.31**	**43.46**	**40.20**	**168.88**	**78.86**	**23.86**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
																		Total:[3]	**486**
percent of total:	0.0%	0.0%	0.4%	0.7%	7.6%	**14.3%**	**4.0%**	**8.9%**	**8.3%**	**34.7%**	**16.2%**	4.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

NOTES:

[1] The mass flux for each subarea is calculated from the assigned specific discharge and concentration for each subarea and the subarea dimensions.

[2] The sum of the mass fluxes for each column in the cross-section.

[3] The total mass flux for each column in the transect; this value represents the mass discharge of MTBE through the entire plume width and depth.

= Zone of NAPL/Water Contact

= Flooded Vadose Soils

Table D-5c
TARGET CONCENTRATION DISTRIBUTIONS IN CROSS SECTION - NAPL Boundary Transect - Flooded Conditions
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

MTBE Concentration, ug/L 1
Flooded:

Concentration, ug/L																			
42 ft msl	**0**																		**1200**
6	0	10	1000	20000	20000	20000	20000	20000	20000	20000	20000	20000	32	10	3	3	3	2	0
2	0	10	1000	20000	20000	20000	20000	20000	829	391	20000	100	32	10	3	3	3	2	0
3	0	10	1000	4932	2387	2387	2387	2387	829	391	391	100	32	10	3	3	3	2	0
12	0	10	316	4932	2387	2387	2387	829	829	157	157	100	10	10	3	3	3	2	0
15	0	5	316	1000	829	829	829	316	316	100	100	10	10	3	3	3	2	2	0
11	0	5	32	120	120	316	100	100	100	32	32	3	3	3	2	2	0	0	0
7	0	2	10	32	32	32	32	32	32	10	10	3	3	2	2	0	0	0	0
32	0	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	0	0	0
- 40 ft msl																			

Benzene Concentration, ug/L [1]
Flooded:

Concentration, ug/L																			
42 ft msl	**0**																		**1200**
4	0	10	513	39600	39600	39600	39600	39600	39600	39600	39600	39600	5	0	0	0	0	0	0
1	0	10	513	39600	39600	39600	39600	39600	2449	2449	39600	278	5	0	0	0	0	0	0
4	0	10	513	3283	3283	2449	2449	6459	2449	2449	2449	278	2	0	0	0	0	0	0
12	0	5	181	3283	3283	2449	2449	2449	2449	2449	278	38	0	0	0	0	0	0	0
15	0	2	78	181	181	843	843	843	843	278	38	5	0	0	0	0	0	0	0
11	0	0	0	5	5	14	14	32	32	5	2	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cumulative Length Across Transect:																			

MTBE Target Concentration, ug/L

Concentration, ug/L																			
48 ft msl	**0**																		**1200**
6	0	0	19	385	385	385	385	385	385	385	385	385	1	0	0	0	0	0	0
2	0	0	19	385	385	385	385	385	16	8	385	2	1	0	0	0	0	0	0
3	0	0	19	95	46	46	46	46	16	8	8	2	1	0	0	0	0	0	0
12	0	0	6	95	46	46	46	16	16	3	3	2	0	0	0	0	0	0	0
15	0	0	6	19	16	16	16	6	6	2	2	0	0	0	0	0	0	0	0
11	0	0	1	2	2	6	2	2	2	1	1	0	0	0	0	0	0	0	0
7	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- 40 ft msl																			

Benzene Target Concentration, ug/L

Concentration, ug/L																			
48 ft msl	**0**																		**1200**
6	0	0	1	87	87	87	87	87	87	87	87	87	0	0	0	0	0	0	0
2	0	0	1	87	87	87	87	87	5	5	87	1	0	0	0	0	0	0	0
3	0	0	1	7	7	5	5	14	5	5	5	1	0	0	0	0	0	0	0
12	0	0	0	7	7	5	5	5	5	5	1	0	0	0	0	0	0	0	0
15	0	0	0	0	0	2	2	2	2	1	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- 40 ft msl																			

= Zone of NAPL/Water Contact

Table D-5d
TARGET MASS FLUX CALCULATIONS - NAPL Boundary Transect - Flooded Conditions
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

MTBE Mass Flux, grams/day[1]:
Flooded:

48 ft msl	**0**																		**1200**
6	0.000	0.001	0.156	0.272	3.127	7.842	0.952	5.994	9.323	58.724	26.100	11.321	0.012	0.004	0.001	0.000	0.000	0.000	0.000
2	0.000	0.002	0.489	0.850	9.770	12.253	2.974	6.622	0.427	0.449	10.195	0.063	0.013	0.004	0.002	0.000	0.000	0.002	0.000
3	0.000	0.009	1.954	0.838	4.665	5.851	1.420	3.162	1.708	1.796	0.798	0.250	0.051	0.018	0.009	0.001	0.002	0.006	0.000
12	0.000	0.006	0.371	0.503	2.799	12.170	4.260	1.902	2.959	2.154	0.957	1.300	0.049	0.053	0.026	0.003	0.002	0.056	0.000
15	0.000	0.007	1.036	0.285	6.076	10.990	5.547	1.571	2.443	1.720	0.765	0.162	0.030	0.010	0.014	0.003	0.003	0.067	0.000
11	0.000	0.012	0.170	0.056	0.647	2.559	0.491	0.364	0.567	0.399	0.177	0.038	0.014	0.015	0.013	0.007	0.000	0.000	0.000
7	0.000	0.000	0.005	0.001	0.015	0.282	0.099	0.073	0.114	0.046	0.021	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- 20 ft msl																			
Column Mass Flux (grams/day)2:	**0.00**	**0.04**	**4.18**	**2.81**	**27.10**	**51.95**	**15.74**	**19.69**	**17.54**	**65.29**	**39.01**	**13.14**	**0.17**	**0.11**	**0.06**	**0.01**	**0.01**	**0.13**	**0.00**
																		Total:[3]	**257**
percent of total:	0.0%	0.0%	1.6%	**1.1%**	**10.5%**	**20.2%**	**6.1%**	**7.7%**	**6.8%**	**25.4%**	**15.2%**	5.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%

Benzene Mass Flux, grams/day[1]:
Flooded:

48 ft msl	**0**																		**1200**
6	0.000	0.001	0.080	0.538	6.191	15.527	1.884	11.867	18.460	116.274	51.677	22.416	0.002	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.002	0.250	1.682	19.345	24.262	5.888	13.112	1.262	2.809	20.186	0.174	0.002	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.009	1.002	0.558	6.416	6.003	1.457	8.554	5.046	11.238	4.995	0.696	0.003	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.003	0.212	0.335	3.850	12.487	4.370	5.619	8.741	33.714	1.702	0.494	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.003	0.256	0.052	1.328	11.179	5.643	4.189	6.516	4.788	0.290	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.002	0.025	0.112	0.068	0.115	0.179	0.060	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- 20 ft msl																			
Column Mass Flux (grams/day)2:	**0.00**	**0.02**	**1.80**	**3.17**	**37.16**	**69.57**	**19.31**	**43.46**	**40.20**	**168.88**	**78.86**	**23.86**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
																		Total:[3]	**486**
percent of total:	0.0%	0.0%	0.4%	0.7%	7.6%	**14.3%**	**4.0%**	**8.9%**	**8.3%**	**34.7%**	**16.2%**	4.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table D-5d
TARGET MASS FLUX CALCULATIONS - NAPL Boundary Transect - Flooded Conditions
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

MTBE Mass Flux, grams/day[1]:

69 ft msl	0																		1200
6	0.000	0.000	0.003	0.005	0.060	0.151	0.018	0.115	0.179	1.129	0.502	0.218	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.009	0.016	0.188	0.236	0.057	0.127	0.008	0.009	0.196	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.038	0.016	0.090	0.113	0.027	0.061	0.033	0.035	0.015	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.007	0.010	0.054	0.234	0.082	0.037	0.057	0.041	0.018	0.025	0.001	0.001	0.000	0.000	0.000	0.001	0.000
15	0.000	0.000	0.020	0.005	0.117	0.211	0.107	0.030	0.047	0.033	0.015	0.003	0.001	0.000	0.000	0.000	0.000	0.001	0.000
11	0.000	0.000	0.003	0.001	0.012	0.049	0.009	0.007	0.011	0.008	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.005	0.002	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- 20 ft msl																			
Column Mass Flux (grams/day)[2]:	**0.00**	**0.00**	**0.08**	**0.05**	**0.52**	**1.00**	**0.30**	**0.38**	**0.34**	**1.26**	**0.75**	**0.25**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
																		Total:[3]	**4.94**
percent of total:	0.0%	0.0%	0.0%	**0.0%**	**0.2%**	**0.4%**	**0.1%**	**0.1%**	**0.1%**	**0.5%**	**0.3%**	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Benzene Mass Flux, grams/day[1]:

48 ft msl	0																		1200
6	0.000	0.000	0.000	0.001	0.014	0.034	0.004	0.026	0.041	0.256	0.114	0.049	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.001	0.004	0.043	0.053	0.013	0.029	0.003	0.006	0.044	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.002	0.001	0.014	0.013	0.003	0.019	0.011	0.025	0.011	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.001	0.008	0.027	0.010	0.012	0.019	0.074	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.001	0.000	0.003	0.025	0.012	0.009	0.014	0.011	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
- 20 ft msl																			
Column Mass Flux (grams/day)[2]:	**0.00**	**0.00**	**0.00**	**0.01**	**0.08**	**0.15**	**0.04**	**0.10**	**0.09**	**0.37**	**0.17**	**0.05**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
																		Total:[3]	**1.07**
percent of total:	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**0.0%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

NOTES:
1 The mass flux for each subarea is calculated from the assigned specific discharge and concentration for each subarea and the subarea dimensions.
2 The sum of the mass fluxes for each column in the cross-section.
3 The total mass flux for each column in the transect; this value represents the mass discharge of MTBE through the entire plume width and depth.

= Zone of NAPL/Water Contact

= Flooded Vadose Soils

Table D-6
Summary of Mass Flux Evaluation
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

	Low Water Condition (Aug 2003):		High Water Condition (4 ft above present):	
	MTBE	**Benzene**	**MTBE**	**Benzene**
Mass Flux, g/day:	**133**	**241**	**257**	**486**
Percent of Mass Flux from NAPL Subareas:	**32%**	**35%**	**61%**	**65%**
Pure Phase Solubility, ug/L:	51,000,000	1,800,000	51,000,000	1,800,000
Mole Fraction - Equilon Data (Equilon 1995):	0.0004	0.022	0.0004	0.022
Calculated **Original** Effective Solubility, ug/L:	20,000	39,600	20,000	39,600
Calculated **Target** Effective Solubility, ug/L:	-	-	**385**	**87**
Calculated Target Mole Fraction:	**-**	**-**	**7.55E-06**	**4.83E-05**
Required Mole Fraction Reduction Factor:	**-**	**-**	**53**	**455**

Table D-7
LNAST Input Parameters, Soil Column 1
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

Soil Type	Height above base of LNAPL (m)	LNAPL Saturation (95% upper confidence limit)			
SW	0.00	0.000	**0.0**	**Base of Layer, base of LNAPL**	
SW	0.01	0.022			
SW	0.26	0.022			Saturated Zone
SW	0.27	0.005			Layer Thickness = 1.01 m
SW	1.01	0.005	**1.01**	**Elevation of Water Level**	
MH	1.02	0.004			Capilary Fringe
MH	1.12	0.004			Layer Thickness = .10 m
SM	1.13	0.001			
SM	1.58	0.001	**1.58**	**Elev of Top of LNAPL**	Vadose Zone
					Layer Thickness = 0.47 m

SW = Saturated Well-Graded Sand
MH = Capilary Fringe Clayey Silt
SM = Vadose Zone Silty Sand

Default Soil Parameters (Van Genuchten Parameters) and Hydraulic Conductivity for each soil type used.

Groundwater Conditions: hydraulic gradient, dh/dx = 0.003

Source Area Parameters:

Initial Thickness of LNAPL:	1.58 m	Note - user-defined thickness since selected LNAPL distribution curve is user-defined
Average depth to top of NAPL:	5.12 m	Note - taken as approximate depth to water minus LNAPL thickness (1.58 m)
Length of NAPL:	137 m	Note - distance from property boundary to approximate dgradient extent of LNAPL
Width of NAPL:	28 m	Note - distance across LNAPL Boundary Transect where LNAPL is present

LNAPL Properties:
Default except MTBE and Benzene fractions, 0.0004 and 0.022, respectively (Equilon Enterprises LLC and Aqui-Ver, Inc. 2001)

Solute Transport Properties:
Default except Vapor Diffusion Efficiency Coefficient = 0.001 as recommended in LNAST Manual for sites with an impermeable cover (API 2001).

Table D-8
LNAST Input Parameters, Soil Column 2
Mission Valley Terminal, San Diego, California
LFR 002-10180-13

Soil Type	Height above base of LNAPL (m)	LNAPL Saturation (95% upper confidence limit)			
SW	0.00	0.000	**0.0**	**Base of Layer, base of LNAPL**	
SW	0.01	0.004			Saturated Zone
SW	0.18	0.004			Layer Thickness = 0.18 m
MH	0.19	0.002			
MH	0.32	0.002	**0.32**	**Elevation of Water Level**	
MH	0.33	0.024			Capilary Fringe
MH	0.95	0.024			Layer Thickness = .77 m
SM	0.96	0.008			
SM	1.61	0.008	**1.61**	**Elevation of Top of LNAPL**	Vadose
					Layer Thickness = .65 m

SW = Saturated Well-Graded Sand
MH = Capilary Fringe Clayey Silt
SM = Vadose Zone Silty Sand

Default Soil Parameters (Van Genuchten Parameters) and Hydraulic Conductivity for each soil type used.

Groundwater Conditions: hydraulic gradient, dh/dx = 0.003

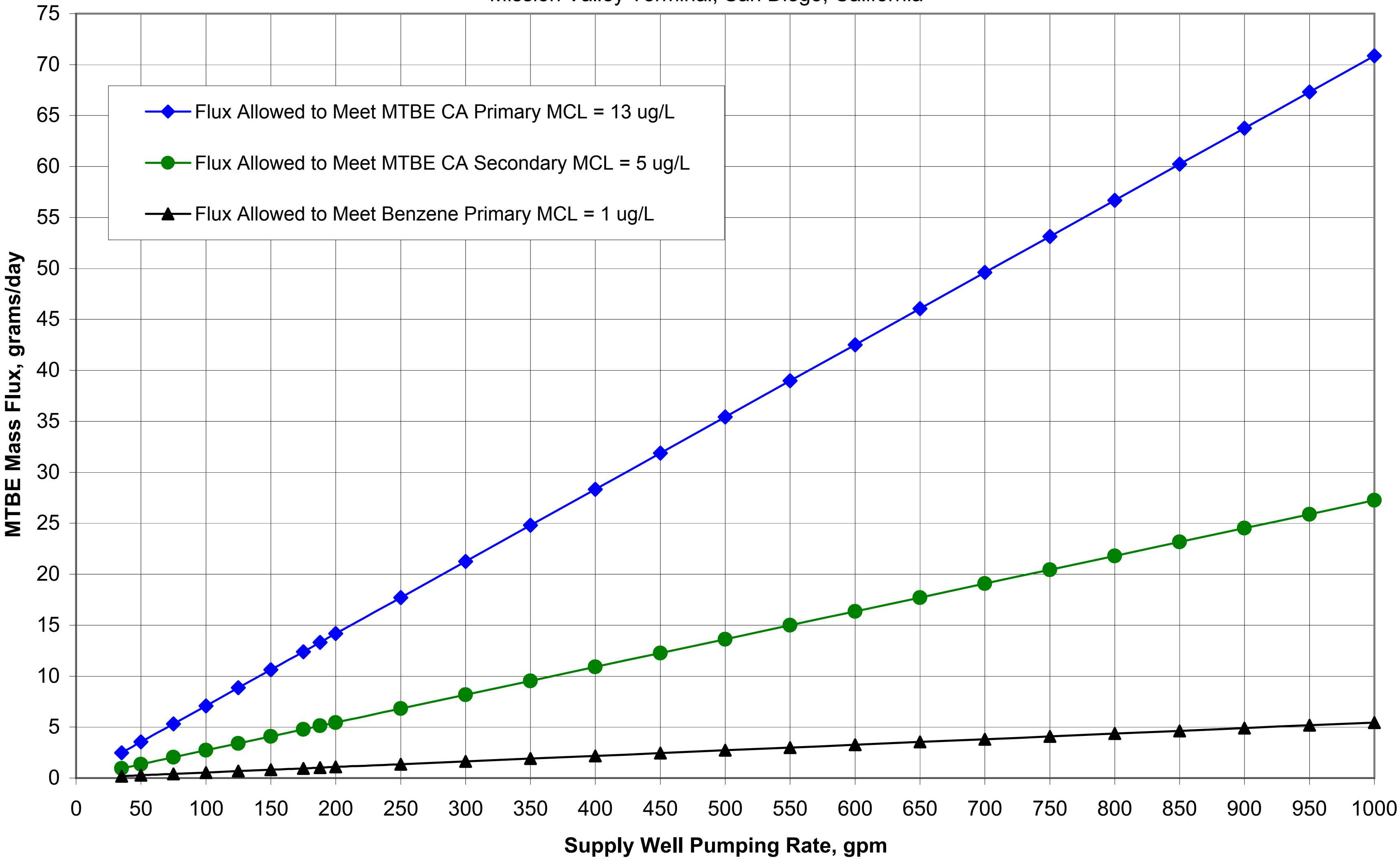
Source Area Parameters:

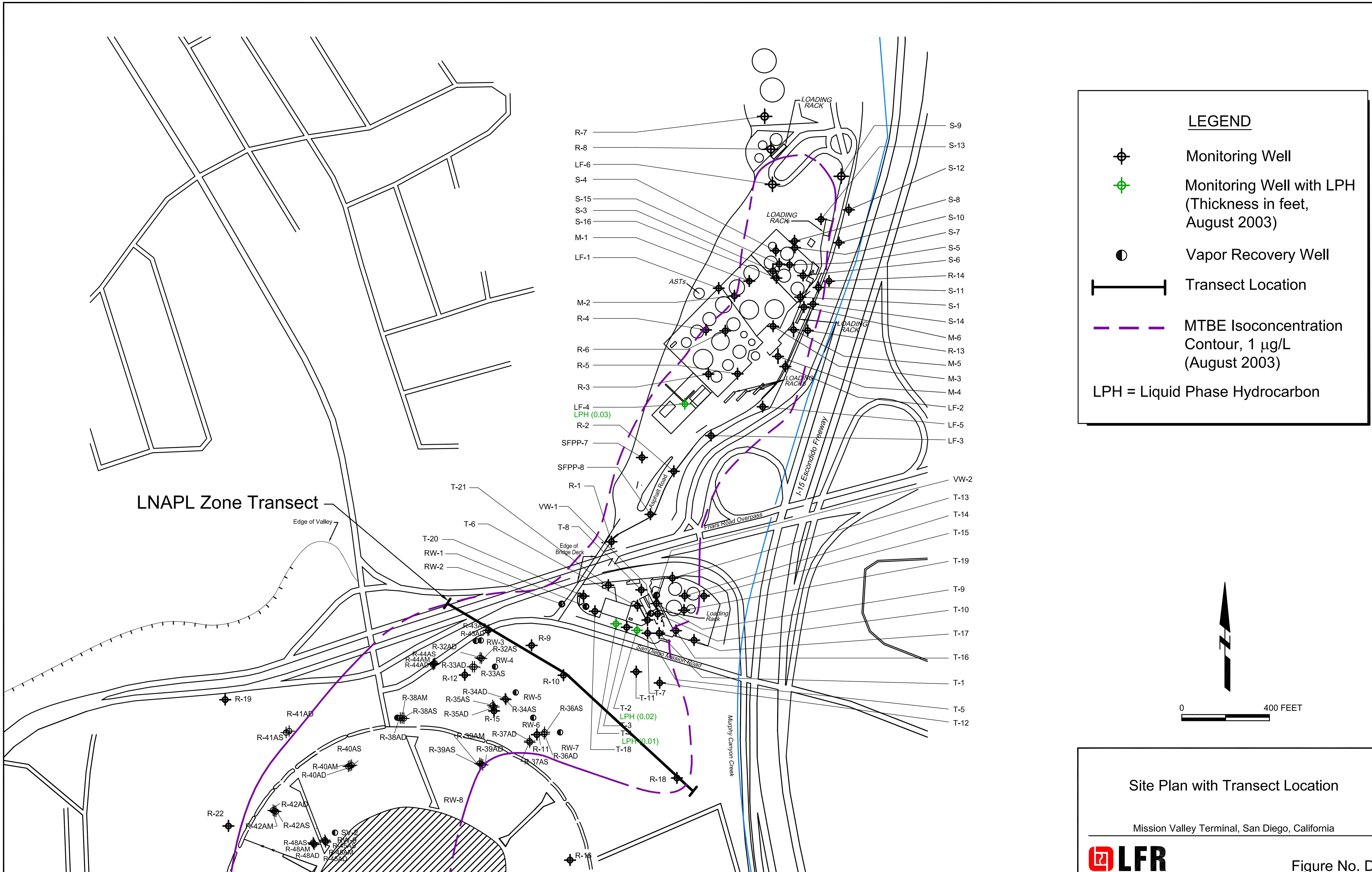
Initial Thickness of LNAPL:	1.61 m	Note - user-defined thickness since selected LNAPL distribution curve is user-defined
Average depth to top of NAPL:	5.09 m	Note - taken as approximate depth to water minus LNAPL thickness (1.58 m)
Length of NAPL:	137 m	Note - distance from property boundary to approximate dgradient extent of LNAPL
Width of NAPL:	37 m	Note - distance across LNAPL Boundary Transect where LNAPL is present

LNAPL Properties:
Default except MTBE and Benzene fractions, 0.0004 and 0.022, respectively (Equilon Enterprises LLC and Aqui-Ver, Inc. 2001)

Solute Transport Properties:
Default except Vapor Diffusion Efficiency Coefficient = 0.001 as recommended in LNAST Manual for sites with an impermeable cover (API 2001).

Figure D-1
Mass Flux Targets for MTBE and Benzene in Groundwater
Mission Valley Terminal, San Diego, California



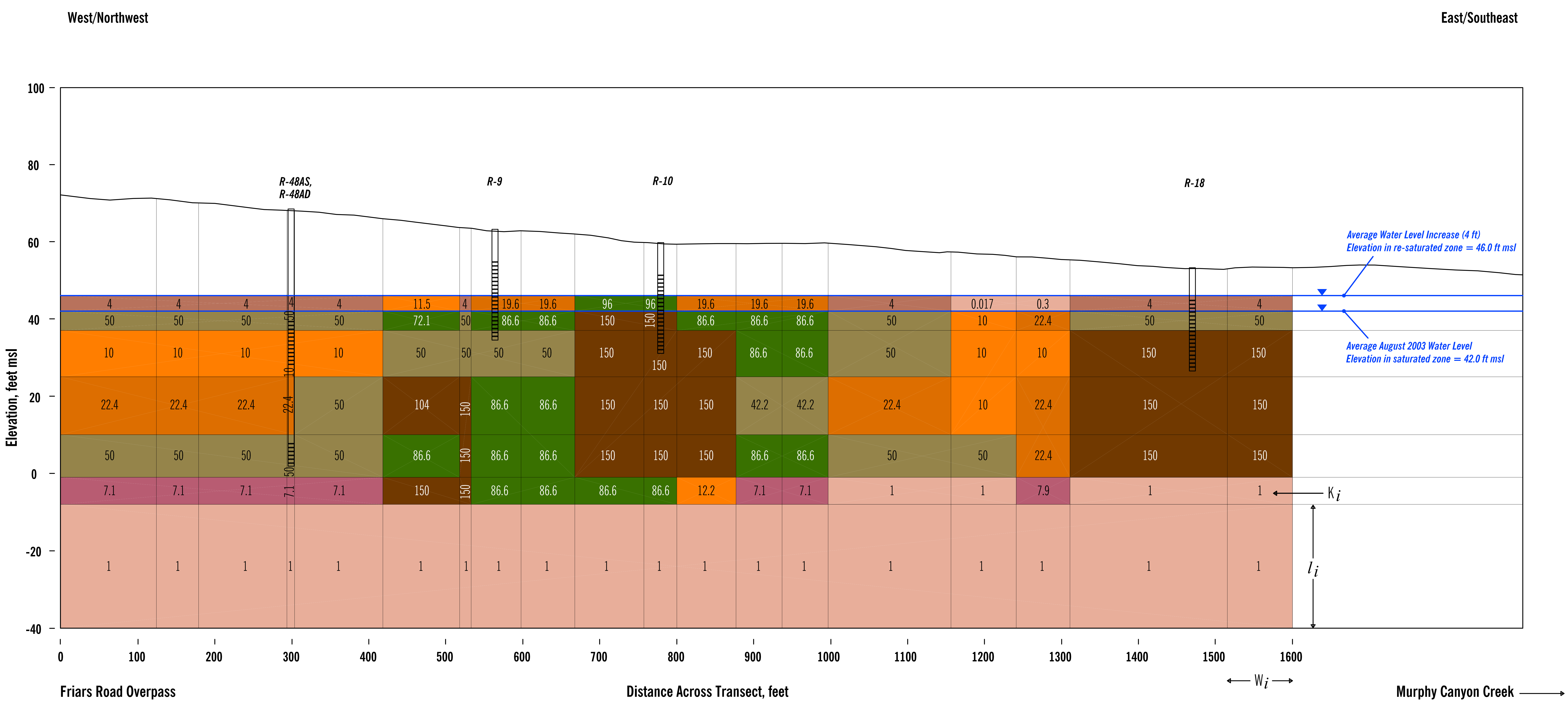


Site Plan with Transect Location

Mission Valley Terminal, San Diego, California

LFR LEVINE•FRICKE

Figure No. D-2



LEGEND

M_f = Mass Flux

C_i = Concentration (µg/l) (see Table D-4a)

A_i = Subarea Dimensions (ft^2)

q_i = Specific Discharge (ft/day)

$\frac{dh}{dx}$ = Hydraulic Gradient (feet/foot)

K_i = Hydraulic Conductivity (feet/day)

Monitoring Well R-9 SCREEN INTERVAL

VERTICAL SCALE: 1"=20' (VERTICAL SCALE EXAGGERATED 5x) HORIZONTAL SCALE: 1"=100'

$$\text{Mass Flux} = M_f = \sum_{i=1}^{n} C_i \times A_i \times q_i \; ; \; q_i = K_i \times \frac{dh}{dx} \; ; \; A_i = l_i \times W_i$$

Notes:

1. Hydraulic conductivity values presented in feet/day.

2. Hydraulic conductivity distribution for the saturated zone is based on results of indicator kriging and were further refined based on the methyl-tertiary butyl ether and benzene plume distributions. Values for the re-saturated zone were estimated from permeability testing.

3. For subareas where more than one hydraulic conductivity value is present, the hydraulic conductivity value is presented is a geometric mean all of the values in that subarea.

feet msl = feet relative to mean sea level.

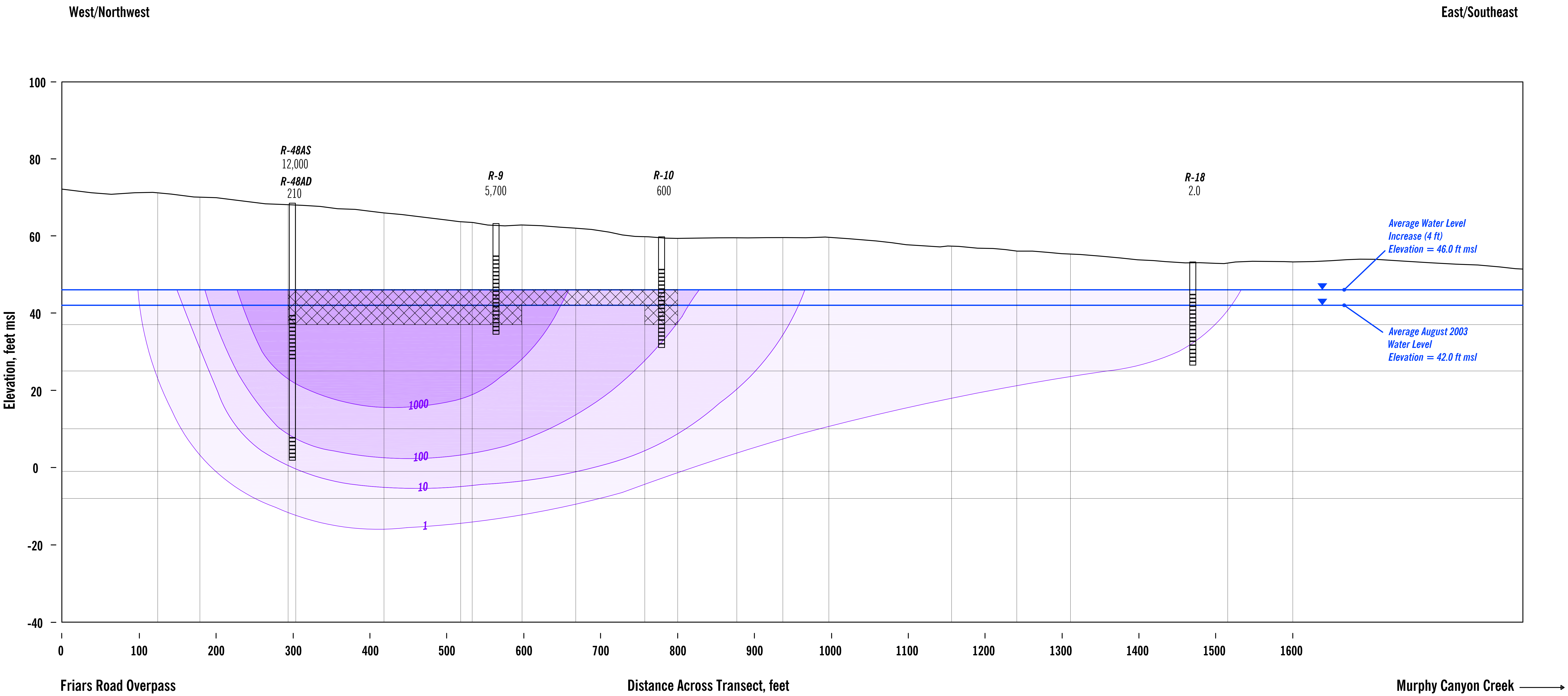
LNAPL Zone Transect Cross Section with Hydraulic Conductivity Distribution

Mission Valley Terminal, San Diego, California

LFR LEVINE•FRICKE

Figure D-3

\\Reliant\graphics\Data\Graphics\10000\10180\013\TRoth\10180_transect.dwg [Property Boundary Transect] 1/30/04 9:15am JLOVING XREFS:



LEGEND

M_f = Mass Flux

C_i = Concentration (µg/l) (see Table D-4a)

A_i = Subarea Dimensions (ft^2)

q_i = Specific Discharge (ft/day)

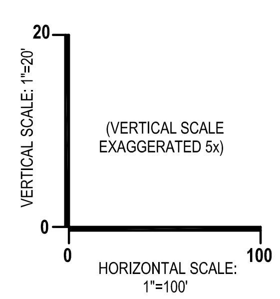
$\frac{dh}{dx}$ = Hydraulic Gradient (feet/foot)

K_i = Hydraulic Conductivity (feet/day)

R-9
5,700 Concentration, µg/l

Monitoring Well

SCREEN INTERVAL



$$\text{Mass Flux} = M_f = \sum_{i=1}^{n} C_i \times A_i \times q_i \ ; \ q_i = K_i \times \frac{dh}{dx} \ ; \ A_i = l_i \times W_i$$

Notes:

See Table D-4a in this Appendix for the assigned distribution of the geometric mean concentrations.

feet msl = feet relative to mean sea level.

100 10 1 *Area of equal concentration (µg/L)*

Subareas where groundwater is in contact with LNAPL (see discussion in this Appendix for details).

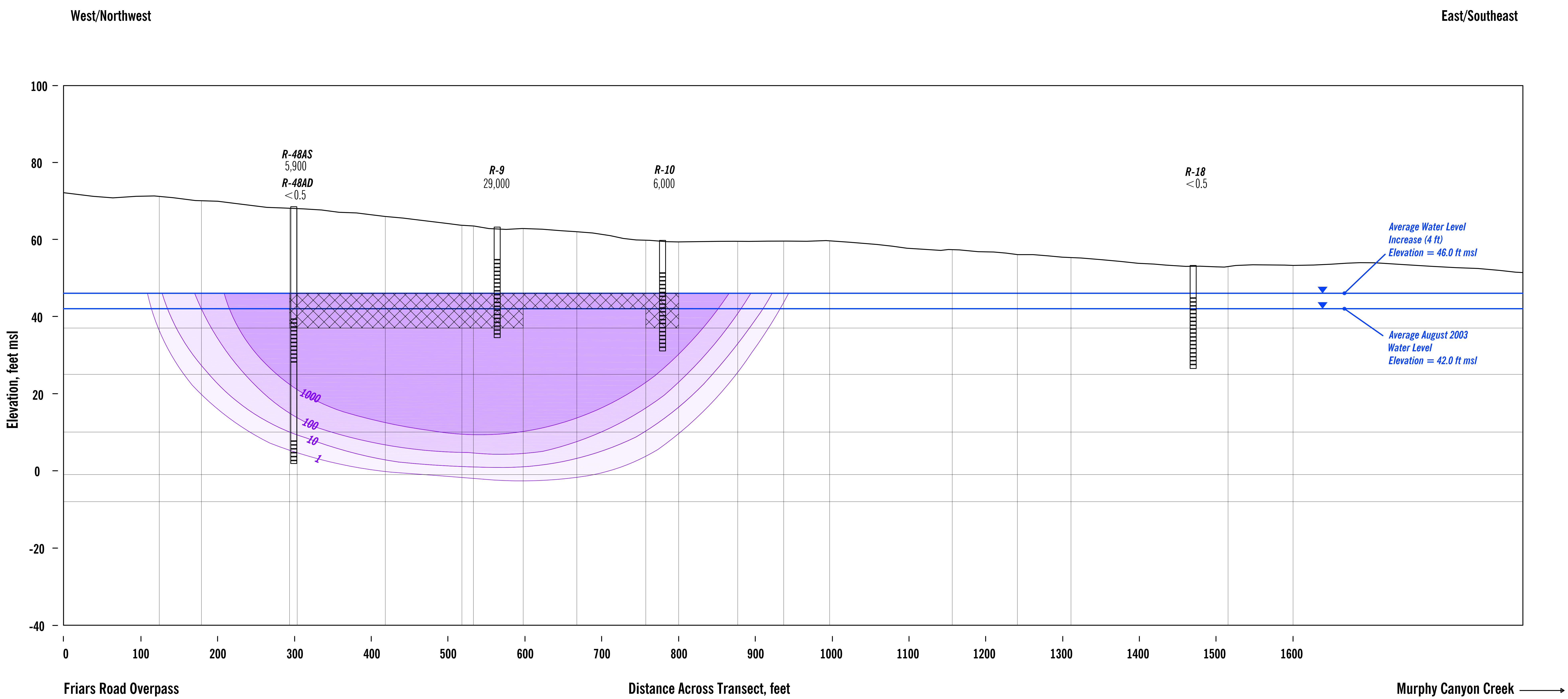
LNAPL Zone Transect
MTBE Cross Section
August 2003

Mission Valley Terminal, San Diego, California

LFR LEVINE•FRICKE

Figure D-4

\\Reliant\graphics\Data\Graphics\10000\10180\013\TRoth\10180_mtbe.dwg [MTBE] 1/30/04 9:18am JLOVING XREFS:



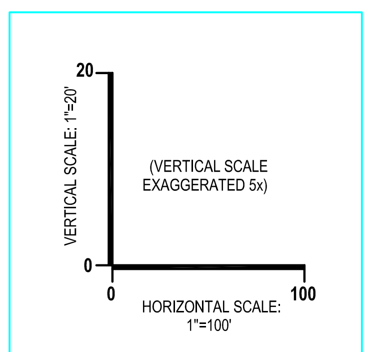
LEGEND

M_f =	Mass Flux
C_i =	Concentration (µg/l) (see Table D-4a)
A_i =	Subarea Dimensions (ft^2)
q_i =	Specific Discharge (ft/day)
$\frac{dh}{dx}$ =	Hydraulic Gradient (feet/foot)
K_i =	Hydraulic Conductivity (feet/day)

R-9
29,000 Concentration, µg/l

Monitoring Well

SCREEN INTERVAL



$$\text{Mass Flux} = M_f = \sum_{i=1}^{n} C_i \times A_i \times q_i \ ; \ q_i = K_i \times \frac{dh}{dx} \ ; \ A_i = l_i \times W_i$$

Notes:

See Table D-4a in this Appendix for the assigned distribution of the geometric mean concentrations.

feet msl = feet relative to mean sea level.

100 10 1 — Area of equal concentration (µg/L)

Subareas where groundwater is in contact with LNAPL (see discussion in this appendix for details).

LNAPL Zone Transect
Benzene Cross Section
August 2003

Mission Valley Terminal, San Diego, California

LFR LEVINE•FRICKE

Figure D-5

Figure D-6
Source Zone Concentration Versus Time - Soil Column 1
Mission Valley Terminal, San Diego, CA

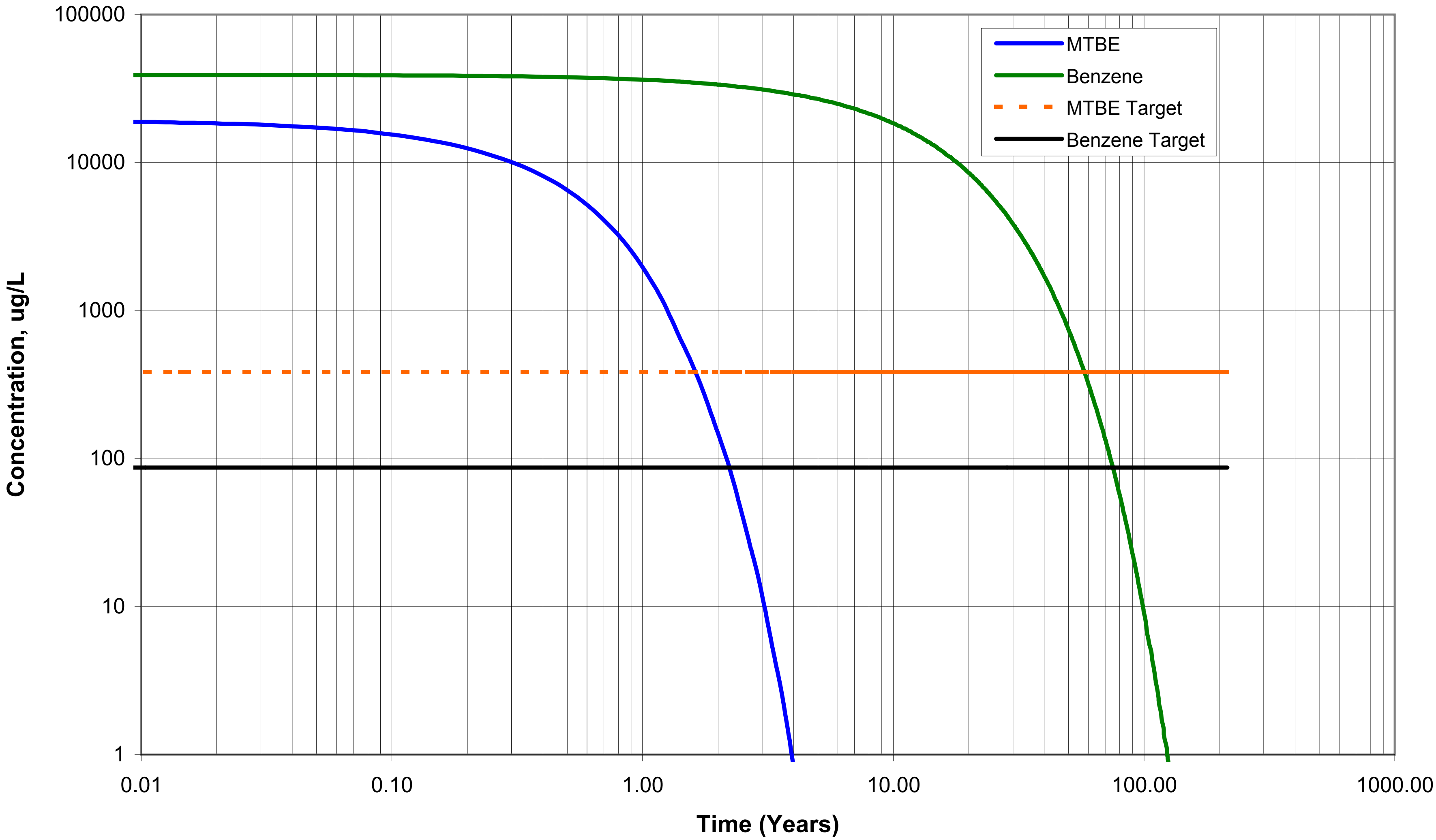


Figure D-7

Source Zone Concentration Versus Time - Soil Column 2

Mission Valley Terminal, San Diego, CA